Sept. 1, 1964 B. G. PERRY ETAL 3,147,327

BLAST FURNACES FOR SMELTING ZINC

Filed Feb. 28, 1961

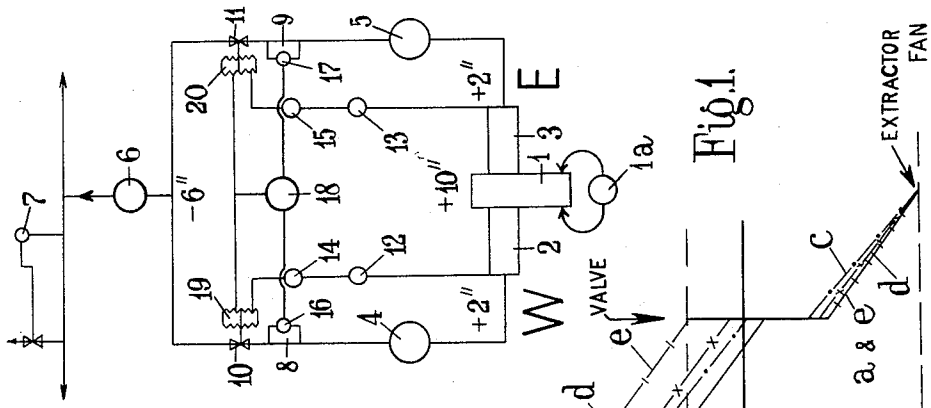


Fig.1.

Fig.2.

INVENTORS
BENNETT GREGORY PERRY
EDWARD IVAN LOWE

BY

Fennic, Edmonds, Morton, Barrows & Taylor

ATTORNEYS

United States Patent Office 3,147,327 Patented Sept. 1, 1964

3,147,327

BLAST FURNACES FOR SMELTING ZINC

Bennett Gregory Perry and Edward Ivan Lowe, Avonmouth, England, assignors to Metallurgical Processes Limited, Nassau, Bahamas, a company of the Bahamas, and The National Smelting Company Limited, London, England, a British company, carrying on business together as Metallurgical Development Company, Nassau, Bahamas

Filed Feb. 28, 1961, Ser. No. 92,391
Claims priority, application Great Britain Mar. 17, 1960
3 Claims. (Cl. 266—24)

This invention relates to blast furnaces for smelting zinc.

In the smelting of zinc by the blast furnace method zinc vapour is produced and condensed.

It may be desirable to divide the outgoing gas flow from the furnace into two gas streams which are passed through separate symmetrically disposed condensers.

The resistance to gas flow offered by these two separate condensers is approximately equal in clean conditions but in the course of the operation the formation of accretions on walls with restriction of the area for gas flow results in alteration of the flow resistance characteristics and this alteration is not necessarily equal in both condensers.

For smooth operation of the condensers and correct temperatures it is necessary to maintain constant flow of gas through the individual condensers and since the total volume delivery through the two condensers (which equals the total flow of gas leaving the furnace) is maintained at a constant value the demand is for a constant ratio of the flow through the two individual condensers. This ratio is normally 1/1, i.e. equal flow through each condenser, but in principle can have any desired value. Ideally also the pressures in the two systems should be the same but these two conditions will be incompatible if accretions build up in an unequal manner.

The control is effected by means of a valve or valves in ducts in the respective condensing systems through which the gases flow. Generally speaking the valves are located after the scrubbing systems through which the gases pass after leaving the condensers but before the extractor fan which may be a single fan for the two condensing systems combined.

It is this location of the valves at the opposite end of the system to that at which accretions occur which makes equal volume flow and equal condenser pressures incompatible conditions.

It would be possible to compare the two volume flows and if one of these were increased or reduced, to make a corresponding increase or reduction in the corresponding duct opening and an increase or reduction in the other duct opening by operating the valves.

The requirement of a fixed ratio of flow rate does not, however, of itself define the position of the dampers in the condenser ducts. Clearly, for any one setting of one valve there is a position of the valve in the duct which ensures that the ratio of flow attains its target value; this means that there is an infinite number of pairs of valve settings which yield the target ratio. The particular combination of settings required is elected in relation to the pressure in the condenser.

Also it is necessary to provide a pressure control for each condenser which operates so that the gas pressure in the associated condenser does not fall below a particular value. Otherwise continued increase in a duct opening might lead to a reduction of pressure in the associated condenser below a critical value, namely, atmospheric pressure, so that air would be introduced into the condenser by suction and would oxidise the zinc vapour which it is desired to condense in metallic form.

We have found that the best results are obtained by a combination of valve settings which simultaneously:

(*a*) Ensures that the flow rates in the two condensers are in predetermined ratio to one another, and

(*b*) Ensures that in that one of the two condensers in which the measured pressures is the lower, the pressure is equal to a predetermined value.

The present invention consists, therefore, of an arrangement for maintaining an equal volume flow in the outgoing gas stream of a blast furnace for smelting zinc having two condensers in which the volume flows are compared and any difference is used to reduce the greater, while maintaining the pressure in the condenser which has the lower pressure at a predetermined value.

The invention further consists in a zinc blast furnace, means for supplying gas under pressure to the furnace at constant rate, two zinc condensers receiving the outgoing gases from the furnace, extraction means for removing the gases from the condensers, valve means between each condenser and the gas extraction means and control means for the valve means for maintaining equal gas flow through the two condensers while maintaining the pressure in the condenser which has the lowest pressure at a predetermined value.

To achieve this result is not a simple matter since as previously explained the effect on the control valves of deviations of pressure in the condensers from the predetermined value is necessarily opposite to that required to restore the equal flow rate of the two condensers.

The arrangement basically consists of a pressure controller for each condenser and a volume ratio flow controller which compares the volume flow through each condenser. These may operate separate control valves or one control valve only may be used for each condenser system which is regulated by the respective pressure controller and the volume controller acting together.

The control instruments which are used are standard instruments which do not operate on the proportional principle but on a system based on a proportional factor plus a time integral factor.

The control exercised by the instrument responsive to pressure and by the instrument responsive to unequal volume flows may be achieved by using a form of valve control which is a double-bellows or bellows with a central partition, operated by pneumatic pressure, from which the valve is operated. Pneumatic pressure on one side of the bellows supplied from the pressure recorder instrument tends to force the central partition one way and pneumatic pressure on the other side supplied from the volume ratio flow controller tends to force it the other.

The pneumatic pressures are supplied from the recording instruments in a manner which is well known.

The volume flows, which may be measured using Venturi tubes, are compared in an instrument which will give an output pressure of an intermediate value when the flows are equal, a greater value when the flow in one condensing system exceeds the other, and a lesser value when the reverse is the case.

This requires that the single pressure output of the volume ratio flow control instrument (see 18 below) will act in opposite sense on the two volume control valve systems.

The condenser pressures can be made to act in the same sense on the two bellows systems controlling the respective valves by inverting the relationship between condenser pressure and instrument pressure for one of the condenser pressure instruments, so that an increase in condenser pressures gives a reduction of pneumatic pressure acting on the associated bellows.

The invention will be further described with reference to the accompanying drawing.

FIGURE 1 is a diagrammatic layout of a blast fur-

nace with two condensing systems according to the invention.

FIGURE 2 is a somewhat idealised graph showing the pressures in the systems, the slopes of the curves indicating volume flow.

Curves (*a*) represent the volume flow through the two clean condensers.

(*b*) represent the immediate result of a partial blockage at the inlet of the west condenser.

(*c*) represent the raised pressure level in both condensers after the valve in the unblocked east condenser has partially closed.

(*d*) represent the returning of the flow rate in the east condenser to normal by the further closing of the valve after the initial slight increase in flow rate due to the build up of pressure in the furnace top.

(*e*) represent the flow rate having been restored to its desired value but with a higher condenser inlet pressure.

In FIGURE 1 the furnace **1** is supplied with air at a fixed rate under pressure from a source **1***a* and supplies two condensers **2**, **3**, which in turn pass the output gases to scrubbing systems **4**, **5**, from which they are drawn by extractor fan **6**. The pressure in the header main on the outlet side of extractor fan **6** is controlled at a constant value by means of pressure controller **7** connected to a valve in the exhaust to atmosphere. The gases pass through Venturi tubes **8**, **9**, and control valves **10**, **11**.

The pressure in each condenser is recorded by the instruments **12**, **13**, and these feed moving pointers of controllers **14**, **15** respectively, each of which supplies a range of pneumatic pressures to one side of the double bellows operating gear of its associated valve **10** or **11**, depending on the spacing between the moving pointer and a fixed pointer.

Instruments **16** and **17** record the volume flow through the Venturi tubes **8**, **9** respectively, and feed the results each to a separate pointer of a common volume-ratio controller instrument **18** which feeds a common pneumatic pressure to the other side of the respective bellows operating gears **19**, **20**, for the valves **10** and **11**.

Some typical actual pressures are shown on the drawing in inches, water gauge indicated by the suffix ". Thus the furnace top is at 10" w.g. and the condenser output at 2" w.g.

In the condition shown there is a pressure of 8" w.g. acting to force gas from the furnace through each condenser. Curves *a* of FIGURE 2 show the initial condition in the two condensers.

Assume a sudden blocking occurs in the condenser **2** and is maintained, the amount of gas flow through **2** is reduced and the pressure at the offtake of condenser **2** will fall to, say, 1" w.g. (see curve *b*). The pressure controllers **12**, **14**, will tend to act to close valve **10** and the common volume ratio controller **18** will tend to act to open it. The two actions will cancel out and the valve **10** will remain in the same position although the output pressures of both instruments have changed whilst maintaining the same differential between them. This change in output pressure of the common volume ratio controller will start to close the other valve **11**, resulting in a rise of gas pressure in the top of the furnace of, say, from 10" w.g. to 11" w.g. This will enable an extra amount of gas to flow through condensers **2** and **3**. The result is shown in curve *c* of FIGURE 2. The pressure in condenser **2** will be brought up to 2" w.g. again but that in condenser **3** will rise above 2" w.g. (see curve *c*). Pressure controller **13**, **15**, and common volume ratio controller **18** will be acting in opposition and cannot move the valve **11**, although the output pressures of both instruments have changed whilst maintaining the same differential between them, until the pressure controller reaches the end of its control range, when, in a manner which will be explained later, the pressure controller **13**, **15**, loses its control over valve **11** and

the volume controller operates the valve in the direction towards its closed position.

The pressure in the furnace is still rising and finally at, say, 12" w.g. brings the flow through condenser **2** to its original value while at the same time valve **11** reduces the flow through condenser **3** to its original value (curve *e*).

If volume flow has been equalised and condenser pressure returned to 2" w.g. in condenser **2** the valve **10** will be in its original position. Valve **11** in closing will have reduced the flow through condenser **3**. This will put up the condenser pressure to, say, 4" w.g.

The instruments and bellows valve control gear are of standard construction well known in the control system art.

In a practical case instruments are used which have an output of pneumatic pressure which can vary, say from 0 to 18 p.s.i. with an intermediate value of 9 p.s.i.

When the volume flows are equal the output from the instrument measuring volume flow difference will initially be 9 p.s.i.

Now the volume flow difference which can occur will vary the pressure on the two bellows controls by 9 p.s.i. from this value i.e. to 0 p.s.i. or 18 p.s.i.

With rising pressure in the condenser above 2" w.g. it is arranged that the pressure recorder will rise to 18 p.s.i. or fall to 0 p.s.i. to leave the common volume ratio controller **18** in control.

In each case to be considered; we will suppose that the initial settings are volume controller output pressure 9 p.s.i. on both sides and pressure recorder output pressure 12 p.s.i. on the one side and 6 p.s.i. on the other side and the valves are in the half-way positions. Increase in condenser pressure on said other side will produce a decrease of the instrument output pressure as mentioned previously.

The 6 p.s.i. pressure recorder side is the side in which an increase of condenser pressure causes the instrument pressure to fall.

On either side making the pressure recorder instrument pressure 9 p.s.i. i.e. the same as that of the volume controller would close the associated valve.

If a blockage occurs on one side (e.g. the west side) the instrument comparing the volume flows instead of sending out a pressure of 9 p.s.i. will send out a reduced pressure which will be, say, 6 p.s.i.

As the valves started at the half-open position the one on said one side would be partially opened from this position (to fully open position if the condenser pressure changes were disregarded) and the one on the other side partially closed from it (to the fully closed position if the condenser pressure changes were disregarded) as a result of the action of the volume controller instrument to equalise the flows.

Condenser pressure, however, will fall on said one side (say from 2" to 1½" w.g.) as the volume flow reduces as a result of the blockage and would fall also if the valve opened due to the action of the volume controller.

The pressure recorder on said one side will counteract this by reducing to 9 p.s.i. to restore the valve position.

The pressure in the condenser is restored to 2" w.g. as previously explained, by the furnace pressure rising.

On said other side the output pressure of the pressure controller will reduce to 3 p.s.i. initially.

Owing to the time integral effect in the pressure recorder instrument on said other side its output pressure will go on rising until it reaches 0 p.s.i. When this pressure is reached the volume controller which is sending out a pressure of 3 p.s.i. at that point assumes control of the valve and closes it beyond the half-way position by sending out a pressure of, say, 2½ p.s.i.

On the other side the condenser pressure can thus only increase.

The net effect will be to restore the volume flow on each side to their original (equal) values.

The pressure recorder output pressure on said one side will be 5½ p.s.i. and its valve would be half-opened again.

If the furnace outlet to the other condenser were to become the more blocked then the movement of the instrument output pressures would reverse and might finish at, say, volume controller 15½ p.s.i. one pressure recorder pressure 18 p.s.i. other pressure recorder pressure 13 p.s.i.

Although the system is designed to equalise the volume flows in the two condensers, one would expect that the general trend would be towards obstruction of the two condenser systems, i.e. the pressure in the furnace and in the less blocked condenser would tend to increase with time.

The volume flow recorder instrument takes no note of this, it only compares volume flows.

There are in fact three modes of action of the system:

(1) When everything is fairly clean both condenser pressures can be on target and the volume equally split between the condensers.

(2) Eventually partial blockages occur and one condenser pressure will be on target and the volume still equally split but the other condenser pressure is above target but not over the limits at which the process can be operated.

(3) As (2) above but the blockages have become so severe that the condenser with the pressure over target has such a high pressure that it cannot be operated. At this stage the *total* volume of gas supplied to the furnace may be reduced as a temporary expedient until it is convenient to shut down for a clean out.

It will be appreciated that in practice it is neither necessary nor advisable to calculate all the necessary constants. Each recording instrument is adjustable for the constant of proportion and time integral constant and experience indicates at what values these are to be set in order to obtain the necessary control.

While one pneumatic control method has been described, it will be appreciated that other pneumatic instruments may be used, since these vary from manufacturer to manufacturer. Also exactly the same functions could be performed by other types of control gear such as electrical.

Various other modifications could be made within the scope of the invention.

We claim:

1. In apparatus for producing zinc metal from a zinc blast furnace, the improvement in combination therewith comprising:

(*a*) a condenser for zinc vapour connecting the upper portion of the blast furnace to gas extraction means to form a flow duct for removing gases from the condenser;

(*b*) a control valve in the flow duct interposed between the condenser and the gas extraction means for controlling the volume of gases passing through the flow duct;

(*c*) a valve controller connected with the control valve for controlling the degree of opening of the control valve;

(*d*) a volume flow recorder associated with the flow duct between the condenser and the control valve for recording the volume of gases flowing through the flow duct;

(*e*) a pressure recorder associated with the condenser for recording the pressure of the gases leaving the condenser;

(*f*) a pressure controller connecting the pressure recorder with the valve controller for sending a signal to the valve controller;

(*g*) a second condenser for zinc vapour connecting the upper portion of the blast furnace to gas extraction means to form a second flow duct for removing gases from the second condenser;

(*h*) a second control valve in the second flow duct interposed between the second condenser and said gas extraction means for controlling the volume of gases passing through the second flow duct;

(*i*) a second valve controller connected with the second control valve for controlling the degree of opening of the second control valve;

(*j*) a second volume flow recorder associated with the second flow duct between the second condenser and the second control valve for recording the volume of gases flowing through the second flow duct;

(*k*) a second pressure recorder associated with the second condenser for recording the pressure of the gases leaving the second condenser;

(*l*) a second pressure controller connecting the second pressure recorder with the second valve controller for sending a signal to the second valve controller; and

(*m*) a common volume-ratio flow controller interposed between and separately connecting each of the two volume flow recorders with its respective valve controller, for sending signals to both of the valve controllers, each of the valve controllers being responsive to and actuated by both the signal from the pressure controller belonging to the same condenser and to the signal from the common volume-ratio flow controller, the directions of the signals being such that the higher the pressure in either condenser, the more the control valve belonging to this condenser tends to open, and the higher the proportion of the gas flow passing through one condenser, the more the control valve belonging to this condenser tends automatically to close while the control valve belonging to the other condenser tends automatically to open, and the relative strength of the signals sent to the valve controllers from the pressure controllers and the volume-ratio flow controller being preset so that control is attained with the pressure in one condenser at a set predetermined value, the pressure in the other condenser being higher, whereby the distribution of gas flow between the two condensers is maintained in predetermined proportions, despite unequal changes in resistance to gas flow in the two condensers due to partial blockage by accretions formed during the course of operations.

2. Apparatus as claimed in claim 1, in which each valve controller consists of a double bellows structure, one side of which is supplied with pneumatic pressure from its pressure controller and the other side of which is supplied with pneumatic pressure from the common volume-ratio flow controller.

3. Apparatus as claimed in claim 1, in which the controlling instruments operate on a system based on a proportional factor plus a time-integral factor.

References Cited in the file of this patent

UNITED STATES PATENTS

1,409,338	Fenton	Mar. 14, 1922
2,761,672	Wilkins	Sept. 4, 1956
2,936,234	Wainer	May 10, 1960
2,964,304	Rice	Dec. 13, 1960
3,014,490	Morris	Dec. 26, 1961